SEWERAGE OF EUROPEAN CITIES.*

(*Continued from page 62.*)

BERLIN.

Population.—1840, 300,000; 1860, 600,000; 1880, 1,118,630.

Area.—Municipal, 15,629 acres; area of lowland, 9,983 acres; area of highland, 4,645 acres; area built up, 6,450 acres.

Dwelling.—Number of houses, about 21,000; number of dwellings to one house, 11.5; average number inhabitants per dwelling, 4.6; average number inhabitants per house, 53.

Water Supply.—Pumped from River Spree, 31.7 gallons per head daily.

Mortality.—Average for a number of years, 30.6. There has been a gradual decrease from 1872, when it was 32.6, to 1879, when it was 27.7—the lowest rate since 1867.

Meteorological.—Temperature, mean annual, 48.20 Fahrenheit. Lowest daily mean, 1850, Jan. 23, —2.44; Highest daily mean, 1865, July 20, 85.18; coldest observed temperature, Jan., 1833, —28.06.

Rain.—Annual mean, 22.32 in.; number of rainy days per annum, averaged for several years, 118.

Maximum storms, July 11, 1858, 2.56 in. fell in 14 hours = .003 in. per minute; .80 in. fell in 20 minutes = .040 per minute.

Topographical.—Situate on both banks of the Spree, a small river rising in Central Germany, and a few miles from its confluence with the Havel River. Low water in the Spree is about 95 ft. above mean tide in the Baltic. The discharge of the Spree, which averages from 100 to 200 ft. in width, is at—

	Cubic feet per second.
Ordinary low-water	1,000
Extreme low-water	506
Ordinary high-water	2,000
Extreme high-water	4,808

The river runs through the city in several arms.

Physical.—The city is closely built up in the central and eastern section. The western contains the parks and villa-residences. The streets are comparatively wide, and are mostly paved with stone blocks. Recently asphalt is being much used.

Geological.—In the older city and lowland the surface to a depth of 5 ft. is of recent formation, either dug over or filled in. Below is alluvial sand from 11 to 40 ft. thick, and below this is diluvial loam and coarse gravel, rising to the subsoil water-level at a few places in the lower city. Near the river there are occasional beds of peat and of infusorial earth in depths of 8 to 26 ft.

Management of Public Works.—Each department is headed by a chief engineer, responsible to the municipal council. The design and construction of the new sewerage works are under a special and temporary department. Other matters and the execution of the works are in charge of division engineers, one for each main drainage area (radial system), who have each a corps of several assistants, according to amount of work.

Design and Construction of Sewerage Works—General System and Alignment.—Combined water-carriage and disposal on sewage farms. As all sewage requires pumping, and as the surface of the city is extremely flat and low, it is divided into 12 independent artificial drainage areas or districts to obtain better gradients and less depth of sewers. Each one is called a "radial system," and they are numbered from I. to XII. The city proper is covered by five, I. to V.; the rest are peripheral.

The sewage from each district is collected at a lowest point, the pumping station, and from here raised through iron mains to either of two farms, one situated to the northeast, the other to the south of Berlin. The stations are situated at or near the river or one of its branches, and the sewers radiate from it over the district. At present only Radial System III. is finished, I. and II. are nearly so, and others have been commenced. The pumps are intended to raise besides the sewage only a first flush of rain-water; therefore numerous overflows are provided to relieve the pumps of any greater quantity. On broad streets, over 60 ft. in width, a sewer has been laid on each side. All sewers are as much as possible connected with each other, and temporarily separated only by valves, in order to avoid dead ends, to flush lower from higher mains (Lindley principle), and to permit the sewage to flow into other sewers in case of stoppage in any one. All pipe sewers are laid in straight lines between man-holes (Rawlinson principle). In general the sewers are divided into collectors, which are deep and built of brick, into pipe sewers for the branches and higher districts, and into storm-water overflows, for which partially old sewers were made use of. The present plan was adopted in 1873, after an inquiry of a commission appointed in 1867. The system is designed by Mr. Hobrecht.

Shape and Size of Sewers.—Circular pipe sewers are used up to 20 in. diameter. Brick sewers are egg-shaped, except some of the larger ones, which are circular, or flat elliptical for want of sufficient height under street. The width of the egg-shaped section is two-thirds its height. The pumping mains are of iron and 1 meter diameter each, except one, which is only three-quarters of a meter in diameter. The size of the sewers is determined by Eytelwein's formula in the following form, for meters:

Circular sewers, running full, $v = 50\sqrt{\frac{r}{2}s}$

$$Log.\ D = 2.0456 + \frac{5\ log.\ r + log.\ s}{2}$$

Egg-shaped sewers, running full,

$$v = 50\sqrt{\frac{4.594}{7.93}rs}$$

$$Log.\ D = 2.2426 + \frac{5\ log.\ r + log.\ s}{2}$$

Egg-shaped sewers, ½ full,

$$v = 50\sqrt{\frac{3.023}{4.788}rs}$$

$$Log.\ D = 2.0803 + \frac{5\ log.\ r + log.\ s}{2}$$

in which v equals velocity in meters per second; r is the mean radius; s the sine of the slope, and D the discharge in cubic meters per second. The quantity of rainfall used for calculation is ¼ in. per hour, of which ¼ is assumed to evaporate, ¼ to penetrate the ground, and the remaining ¼ (7 millimeters per hour) to enter the sewers.

The quantity of sewage estimated is 130 liters (30 gallons) per day per inhabitant, of which one-half runs off in 9 hours, and for 800 inhabitants per hectare (324 persons per acre). At present there are only half this number. The minimum size for pipe sewers is 8 in.; maximum, 20 in. The brick sewers are classified into eleven types, varying from one meter to two meters in height.

Depth and Grades.—The depth of cellars was regulated by the subsoil water, which stands at + 1 meter above mean water near the river, and at + 2.2 meters at the upper end of the lower city. Cellars must be 1 ft. above subsoil-water level. Depth of pipe sewers varies from 1 meter to 4 meters below surface, and of brick sewers, which are laid deeper to act as collectors, from 2 meters to 5 meters. The latter are often below subsoil-water, and are made water-tight with great care. The grades are, as a rule, very light, on account of the flatness of the country. The minimum grades used are for:

Sewers that can be walked through	1:3000
Sewers that can be crawled through	1:1800
Pipe sewers	1:800

Pipe sewers frequently have a drop in the man-holes.

Junctions, Connections, Overflows, Outfalls.—The junctions of large sewers are generally made at right angles, except where streets join at acute angles. They are usually in rectangular chambers, with a cylindrical arch, and in a few of which there is a tongue. Funnel arches are avoided. When curves are made to enter the chamber, they mostly have a very short radius. No allowance is made for loss of head in the curves. Overflows, of which there are a great number besides those at the pumping stations, are arranged so that they can be adjusted, with regard to the height of water in the river, by iron oars of square section (2 in. by 2 in.), which are placed loosely on each other across the opening and form a dam, which, therefore, can be raised and lowered any distance at pleasure. These dams are used to prevent the ingress of river-water during its high stages. There are two ultimate outfalls for the sewage—one on the Osdorf farm, the other at the Falkenberg farm. At present much of the sewage still flows into the Spree.

Ventilation.—The ventilation of sewers is achieved by perforated man-hole covers in the middle of the street, by the street gully inlets and by the soil pipes of the houses. No objectionable odor has been noticed to arise into the street, and the air in the sewers themselves has but a slight smell.

Man-holes.—The man-holes are generally situated directly over the sewer and are covered by a circular cast-iron grating, open near the periphery and containing blocks of wood in the middle for deadening noise. One inch or two below the cover is a sheet-iron plate to catch street dirt, with holes for ventilation in the middle. The man-holes are descended by cast-iron steps set into the wall. Man-holes are placed at all street crossings and changes of directions; otherwise they are from 200 to 300 ft. apart.

Gullies.—The gullies have a horizontal inlet in the gutters, the grating being 15¾ in. by 19¾ in. They have a catch-basin 26 in. square and 34 in. deep below the outlet. The entire depth of the gully is 7 ft. 4 in. below the gutter. Gullies are never placed at intersections or near crossings, but in the block.

Pumping Stations.—There is to be a pumping station for each radial system. It is intended to pump, besides all sewage, an amount of rain-water of equal quantity. The following notes refer to system III., as it is the only one entirely finished. The rest will be in similar proportions. The station contains buildings for engines, boilers, coal, employés, etc., a well for water of condensation, a large circular catch-basin, with screen and an overflow to river. There are 6 engines (Woolf's horizontal), two coupled to one fly-wheel, with a total of 360 horse-power, driving six pumps, with a capacity of 1,000 cubic feet per minute. Only three of the pumps are ordinarily in use, the other three being kept for rainy weather. In 1878, 4,839,400 cubic meters were pumped to Osdorf, requiring 25,500 hectolitres coal at a cost of 33,500 marks (1,278,280,000 gallons, with 3,330 cubic yards coal, costing $8,400). The lift to the southern farm, Osdorf, is 75 ft.; to the northern farm, Falkenberg, 105 ft.

Miscellaneous.—For crossing the canals there are four pipe bridges and one inverted syphon.

Materials and Construction.—Materials used for sewers are pressed brick and terra-cotta pipe. The ordinary sewers are all pipe; the main collectors are brick.

The brick-work is made water-tight with the greatest care, because all of the ordinary flow of sewage must be pumped. Wedge-shaped bricks are used for arches, of four patterns for diameters from 1 meter to 2 meters. Bricks molded to circular curves, both headers and stretchers, are used for man-holes. Size of ordinary bricks is 9½ in. by 4¾ in. by 2¾ in. Pipe sewers are also laid with greatest care, from the lowest point upwards. The pipes are jointed with gasket and puddled blue clay on the outside, and cement from the inside if the pipe is large enough. This jointing has given perfect satisfaction. The foundations for sewers are usually concrete, from 1 ft. to 2 ft. 6 in. deep.

Statistics.

Radial system.	Area, acres.	Inhabitants, about.	Houses.	Inhabitants per house.	Inhabitants per acre.
I	670	103,000	1,190	87	152
II	862	167,000	2,860	58	192
III	964	107,000	2,860	37	110
IV	2,130	244,000	4,060	60	113
V	1,819	194,000	2,830	69	106
VI	1,001	46,000	720	64	46
VII	642	36,000	770	47	55
VIII	1,413	20,000	300	67	14
IX	1,258	11,000	240	46	9
X	971	35,000	550	64	36
XI	828	6,000	110	55	7
XII	430	8,000	120	67	18

Length of sewers finished December, 1880:

	Miles.
Pipe	113
Brick	13

Dwellings (not houses) connected, 30,000.

Distance from pumps to southern sewage farm, 8 miles.

Lift of pumps, 70 ft.

Sewage reaches farm from extreme dwellings in 5 hours.

Greatest calculated dilution of sewage at the moment when overflows begin to act, 1 to 8.186.

Greatest dilution when sewers are running full, 1 to 158.2.

IN HOUSES.

Sewer connections are obligatory, since 1874, as soon as sewer is laid in front of property. All excrements, waste and rain-water must be led into sewer. Cess-pools are prohibited. Owners must submit a plan of a complete house-drainage for examination; and it must be executed within six weeks after approval. The execution is subject to rigid inspection.

Disposal of Sewage.—All of the sewage is to be pumped and distributed over two farms for irrigation and filtration; one to the northeast, for the part of the city north of the Spree; the other to the south, for the southern portion. The former is at Falkenberg, 6 miles from the center of Berlin, with an elevation of 102 ft. above the Spree, and an area of 1,830 acres; the latter is at Osdorf, 9 miles from the center of Berlin, with an elevation of 72 ft. above the Spree, and an area of 2,050 acres.

A novel feature are the winter basins into which the sewage is turned, after vegetation ceases, to a depth of 2 ft., and allowed to soak away. The odor from them is very great, but no houses are within a mile. In the spring the ground is plowed, and summer grain of excellent quality grown upon it. The Falkenberg farm is not yet prepared. Osdorf receives the sewage from Radial Systems I., II. and III. through two mains, 1 meter in diameter each. The farm is divided into fields, meadows, vegetable gardens and winter basins, which are fields in summer. About 1,000 acres are at present prepared and operated. About 0.27 gallon per second per acre is delivered to the farm. The city owns and operates the farms. Irrigation was begun systematically in 1873.

*Mr. Rudolph Hering's Report to National Board of Health, 1881.

MAINTENANCE OF SEWERAGE WORKS.

Appliances.—Pen-stocks are not used. The pipe sewers are flushed by having wooden plugs inserted and drawn when sufficient water has accumulated, or by using flaps for the same purpose. The large brick sewers are cleaned by hand with scrapers and shovels.

Method.—About every two weeks all pipe sewers are flushed, generally with hydrant water. For this purpose the ends of the pipes in a man-hole are closed either by flaps or plugs, the man-hole itself is filled with water by a hose attached to the nearest fire-plug, and the flap of the lower pipe is raised, which allows the water to rush through it with an initial head of 6 to 10 ft. Beginning at the highest point the silt is flushed from section to section until it is discharged into the brick sewers, where the greater quantity of water and the average velocity of 1 ft. 8 in. generally removes most of the sediment. The brick sewers are inspected, walked through and cleaned once in three weeks. The cleaning in the principal streets is done at night. One gang cleans about 660 ft. of pipe in one night, and removes ¼ to 2 cubic yards of silt.

In 1878 there were pumped from System III. to the farm 3,505,150 gallons; in 1879, 3,716,604 gallons. In the latter year this quantity has been estimated to consist of 9.1 per cent. rain-water, 1.6 per cent. of water used for flushing, the rest of sewage proper, being 1,358 gallons per house and 32 gallons per head daily.

COST OF SEWERAGE WORKS.

Construction.—Total cost of radial systems up to 1880:

I.	Rad. system nearly finished	$1,225,000
II.	" " " "	1,575,000
III.	" " finished	1,526,000
IV.	" " nearly finished	2,400,000
V.	" " " "	2,156,250

Cost of materials: 1,000 bricks cost $7 to $10; cement is worth $2.25 per 400 pounds; iron pipe, 2 cents a pound; puddled clay, ready for use to join pipes, $6 to $8 per cubic yard; traps for house connections, $4.50, including laying; 1 square yard of sheet-piling in place costs $1.75.

Cost of labor:
Laborers, 5½ cents per hour.
Mechanics, 8½ cents per hour.

Excavation costs 80 cents a cubic yard above, and 60 cents below subsoil-water, including pumping.

Brick sewers, 3 ft. 3 in. by 2 ft. 6 in., cost $5.40 per running foot.

Pipe sewers, 20 in. diameter, cost $3.08 per running foot.

Branch pipes to houses are laid at owner's expense.

Cost of ground for Osdorf farm, per acre	$166
Cost of preparing ground, per acre	62
Cost of carriers, per acre	62
Cost of subdrainage, per acre	45
Total per acre	$335

Total cost of farm (2,050 acres), $686,750.

CORRESPONDENCE.

CENTER OF GYRATION.

EDITOR ENGINEERING NEWS:

In your issue of March 4 you seem to intimate that the use of radius of gyration is mere "nomenclature" and "affectation of precision," and that Rankine makes no mention of it in his A. M. This is, I think, erroneous. Its use is principle, not nomenclature, and Rankine does use it. On page 364 he states that in place of $\frac{l^2}{h^2}$ we must put $\frac{l^2 S}{12 J}$ where J is least moment of inertia. Now $\frac{J}{S}$ is r^2 or square of radius of gyration, as he defines it on pages 514, 515 of A. M. He doesn't mention it by name on page 364, probably because he has not yet defined the term. But this is of little consequence, as he really uses it.

The formula $\frac{l^2}{h^2}$ you seem to like so much is but a special case of a more general formula. There is no special "principle" in $\frac{l^2}{h^2}$, but there is in $\frac{l^2}{r^2}$.

You thus seem to me to be in the position of advocating a special case and at the same time rejecting the general formula from which that special result is derived.

You ask the practical advantage of $\frac{l^2}{r^2}$. It is simply that for such sections as ⌐ ∩ + T |, etc. We do not know what to take as the "least diameter." What would you take it in such cases? If then $\frac{l^2}{r^2}$ enables us to apply the formula to cases to which $\frac{l^2}{d^2}$ does not apply, is there not some real advantage in its use?

Let me illustrate. In the general formula for P of Gordon, the form of which is theoretical, although the constants are empirical, the moment of inertia J occurs. Now, this is always equal to Ar^2 where A is area. Hence unit strain $\frac{P}{A}$ comes out *generally* as a function of r^2. But in the *special case* of a rectangular section $J = \frac{1}{12} bd^3 = \frac{1}{12} A d^2$, and hence $\frac{P}{A}$ *in this special case* comes out as a function of d^2. Now, to accept the latter result as general and condemn the other as "affectation" seems to me, if I may say it without intending to be offensive, a good illustration of what too often happens when a "practical man" gets hold of a formula without knowing its derivation.

First he misapplies it and overestimates its generality. Second, he regards the more general form, which really lies at the basis of his own formula, with suspicion. He may even talk contemptuously of "nomenclature" and "affectation of precision" and "wiseacres," and intimate that the latter rather like to muddle up his simple formulas with learned terms without real value. How unjust this is may be seen from the above, and the impression it gives those who understand the position is not favorable to the "practical" man.

[A. J. D. B., asks, "What is a wiseacre?" According to Webster, the first or leading definition of wiseacre is, "a learned or wise man," as, "Pythagoras learned much, becoming a mighty *wiseacre*." Now it is true we had no reference to this meaning of the word when we used it; indeed, had we known there was any ambiguity in the import of the word, we should have sought other expression for an idea which would be more in accord with the second definition of Webster, *viz.*: "One who makes undue pretension to wisdom," not applying it by any means to Rankine, who laboring in his vocation unquestionably exhibited great learning in a chosen field. But some of his admirers have mistaken a parrot-like facility on their own part for adopting the form of speech of their master, for the wisdom which was presumed to lie behind it. These are the wiseacres to whom we had reference.

A. J. D. B.'s letter which appeared in ENGINEERING NEWS of the 4th inst., under signature *, was not seen by us until it appeared in the page proof, too late for answer in that number, but the above taken in connection with our article on the "Radius of Gyration" in number 9 of the NEWS, will, we hope, be considered as satisfactory.

The latest communication, which appears in the present issue under the signature "*," from the same source, calls for notice, and we gladly avail of this occasion to define our position on this and kindred branches of quasi science, which appears in the editorial columns for this week under the head of "Applied Mathematics."

We return to "*."

In our answer to a correspondent in the issue of March 4, we referred to Rankine's formula for strength of columns, and quoted from p. 362 of his A. M. (our copy 3d edition, 1864) for the formula known as Gordon's, which Rankine recommends for use in determining the strength of pillars and struts, wherein he states positively, in italics, as follows: "That the additional stress due to bending is to the stress due to direct pressure in a ratio which increases as the square of the proportion in which the length of the pillar exceeds the least diameter;" and it is the presence in this formula of a recognized ratio between the length and least thickness of columns, when considering their strength to resist bending, that we said that this "formula carried on its face a principle." In the article which follows, p. 363, a table is introduced for practical use, wherein the different ratios of $\frac{l}{h}$ are the headings of the columns for the varying coefficient of wrought and cast-iron, and so far from $\frac{l^2}{h^2}$ being regarded by him as a special case of a general formula, he has no other to offer at that date more general than those of Gordon's, and explains it as founded on a mode of investigation partly theoretical and partly empirical, derived from a theoretical formula of Tredgold, which had fallen into disuse, and which Lewis Gordon had revived by determining the constants by comparison with those of Hodgkinson's experments. The empirical formula of the latter, derived from some hundred experiments on wrought and cast iron and steel is also given, both in this and his work on engineering, and we would remark parenthetically that the value of these experiments is still recognized by practical engineers, and in the 41st edition of "Haswell's Engineers' and Mechanics' Pocket Book," issued within the past week, in a revised form brought down to date, no other formula is given for the strength of columns and struts than that of Hodgkinson.

But to return to the radius of gyration. Nowhere in the third edition of Rankine's "Applied Mechanics," nor in his "Engineering" does the radius of gyration appear as a factor in computing the strength of columns, but its investigation is confined wholly to rotating bodies. But in Rankine's "Useful Rules and Tables," published a couple of years subsequently, no reference is made to any other than the new formula for pillars and struts, viz.:

$$\frac{P}{S} = \frac{f}{1 + \frac{l^2}{cr^2}}$$

and tables are given for various values of r^2, which method, being in its derivation highly analytic, was undoubtedly well suited to exercise the faculties of the students of Glasgow University, and so far served a purpose there as elsewhere; but unless translated into the vernacular is of but little use to the engineer, without the latter has a talent for abstruse calculation. The engineer must not take the mere dicta of mathematicians for his factors, but must understand their meaning as well. The following is the simplest explanation (from Trautwine) of the meaning of this r^2:

"Suppose that the shortest distance from the axis of a body supposed to revolve to each individual particle of the body has been measured: also that each of these distances has been squared, and that each square has been multiplied by the weight of the particle to which the distance was measured; also that all these last particles are added into one sum; that sum is the moment of inertia of the body. In practice, suppose the body to be divided into portions of a cubic inch or some other size, and use these instead of the theoretical infinitely small particles. When the moment of inertia of a surface instead of a solid is required, the surface must be supposed to be divided into an infinite number of small areas which must be used instead of the weights of the particles of the solid body. If the moment of inertia is divided by the weight of the entire solid body, or by the area of the entire surface, as the case may be, the square root of the quotient will be the *radius of gyration* of the body or the surface. If the length of the radius of gyration be laid off perpendicular from the axis, it will reach to the center of gyration, the moment of inertia of the body being its weight into the square of the radius of gyration."

Now we submit that there is a complexity about this r^2 which does not obtain in the use of d^2 in Gordon's formula, and which can only be justified upon the supposition that greater accuracy is thereby attainable, or that the determination of the value of d is not sufficiently assured in all cases—neither of which is the fact; for computations by either method in the sections ordinarily in use give sensibly similar results; while if the engineer be unable to determine by inspection in which direction a column is most flexible in order to fix the value of d for substitution in Gordon's formula, the use of the least diameter of the figure as a circle, within its bounding surfaces, if taken for this value of d, will give as reliable results as by any other known method, particularly as a factor of safety is indispensable by either method.

The complacency with which "Young America" regards his presumed success in grappling with the arcana of applied science is truly refreshing, and we are not disposed to repress the evidences of his progress, such as it is, but would suggest that the comments of "*" upon our presumed ignorance of what has been accomplished in scientific investigations would have been equally happy without the unbecoming sneer at a highly respectable though humble class of truth-seekers; and in response to his last paragraph in particular we have great cause for regret that we should have unwittingly given one whose knowledge of the subject is so vast an unfavorable impression of "practical men."]

THE SHAPE OF OUR EARTH.

CINCINNATI, March 8, 1882.

EDITOR ENGINEERING NEWS:

My attention has been called to certain remarks in your issue of Feb. 25 upon my paper on *the shape of the earth*. Those remarks seem calculated to convey the idea that the inequalities in water-level caused by mountain ranges are insignificant in amount, an idea as widespread as it is erroneous.

The assertions made in my paper, and which I now reaffirm, were not made, as you seem to think, upon the strength of mathematical symbols alone,

but upon competent observations and numerical calculations of the amount of such inequalities. I regret that the abbreviated report which came under your notice did not contain at length the statements in the original paper. Permit me now to detail some of the facts upon which that part of my paper was based.

And, first, it has been discovered that local attractions deviate the plumb line in almost all localities on the earth's surface to measurable amounts from the direction it would have were the earth an homogeneous ellipsoid of revolution. Deviations as great as 30″ of arc have been observed, and deviations of one-half or one-third that amount are not infrequent, even in comparatively level country. Now, what does this imply? Assuredly, it signifies that water level has a slope of that amount at that locality; and that the common observation, "water runs down hill," is a mistake, for it would certainly run up hill at such places. It further signifies that the astronomical latitude of an observatory, determined in the usual way, by reference to the plumb-line, would be erroneously determined to the full extent of the north and south deviation of the plumb-line. Were that 15″, the observatory would be 1,500 ft. and more north or south of its supposed parallel. I cannot regard nearly one-third of a mile an insignificant error, in comparison with that permissible in such a determination, which is a few feet at most. The facts as to the deviation of the plumb-line can be verified in the reports of our Coast Survey and other like surveys in Europe and India.

A parallel of latitude run by the plumb line and stars alone would bear a striking resemblance to a ribbon in the wind.

Secondly, a computation has been made by the distinguished physicists, Thomson and Tait, the results of which are to be found in their Treatise on Natural Philosophy, page 638, vol. 1, first edition, where it is stated that "a set of several broad mountain chains and valleys, twenty nautical miles from crest to crest, or hollow to hollow, and of several times twenty miles extent along the crests and hollows, and 7,200 ft. vertical height from hollow to crest, would raise and lower the level by 2½ ft. above and below what it would be were the surface levelled by removing the elevated matter and filling the valleys with it."

In such a very moderately mountanous country as that supposed, the surface of water would then present a series of crests and hollows 20 miles apart, in which each crest would be 5 ft. above the bottom of the hollow. Now, Mr. Editor, if that be called an insignificant deviation, I beg leave to say that I cannot so consider it. And the statement is on the authority of Sir William Thomson, the first mathematical physicist of the age.

Should you still doubt the accuracy of these statements, please question my esteemed friend Professor Merriman, whose name you mention, or any of the eminent geodetists of our Coast Survey, who are practically familiar with the matter.

Yours very truly, H. T. EDDY.

[The above writer is assured that our remarks on this subject, to which he takes exception, grew out of no distrust whatever as to the entire correctness of his statements as to the fact or the principle involved, and we are happy to find that they were effective in eliciting comment from one so well qualified to give the needed light upon the subject.]

TUNNELS VERSUS BRIDGES.

PORTLAND, Or., March 1, 1882.

EDITOR ENGINEERING NEWS:

I ask the privilege of bringing the following before the civil engineers:

I believe that a vast saving could be made in time and perfect safety accomplished by adopting the plan of tunneling the rivers instead of bridges. Many years ago we had to haul the iron across the Brazos River, in Texas. As it was necessary to get it across the river in order to get the bonus of $6,000 per mile, we built a pile bridge in the river, which was over 40 ft. below the bank; adopted vertical curves, laid the track and did our work without accident. The impetus of the cars going down forced them up on the opposite sides; our levels were equal on both sides.

Now, sir, this plan I wish to bring to the notice of engineers, as it would be safer than bridges where they must have long spans and way for boats, which are always liable to accidents. The tunnel would cost less in many instances; there is no trouble about it. The water in the boiler might be objected to; in this case it is a matter for the scientific engineer to explain the proper curvature that would be safe. There is no trouble in going up again, as already explained.

The engineer must necessarily take soundings of rivers before he can build a bridge. These soundings would do for a tunnel with the proper allowance below the river bottom for the top of the tunnel. They might go down to a point of safety; all would depend upon the nature of the bottom, and care should be taken that the approaches should be placed above high-water mark.

If this plan were adopted, instead of high trestling, partaking of the balloon, and engineers of prominence were to act upon it, a great saving and any amount of good could be done.

I learned my profession in England; it was the Brunel school—the man who built the tunnel under the Thames—it was looked upon as wild and visionary.

I hope, sir, you will give these ideas a place in your valuable journal, and send me a copy, to the office of the N. P. R. R., in this city.

JOHN DOHERTY, C. E.

THE METRIC SYSTEM.

ENGINEER'S OFFICE, MEXICAN CENTRAL R. R., GUANAJUATO, Mexico, Feb. 16, 1882.

EDITOR ENGINEERING NEWS:

I desire to be placed on the record as advocating 20 meters as the length of the standard metric chain.

In my communication which appeared in your issue of Jan. 7 I merely gave what is the practice on one of the Mexican railways, for the information of your readers. In fact, in an article published some two and a half years ago in your paper, I strongly and urgently advocated 20 meters as the proper length, and for reasons not necessary to repeat here. Since then I have had considerable practical experience with the metric system, and so have no occasion to change my opinion in regard to the length. In the same issue (Jan. 7) appeared a communication from Mr. Bradford, in which he takes numerous exceptions to the metric system when applied to railroad work. It is certainly not the fault of the metric system when the application of the same is not properly made, as witness the adoption of the 25-meter chain.

The same objection could logically be brought to bear upon the foot system if the chain of that system consisted of 75 ft. instead of 100 as at present.

But with a 20-meter chain I cannot conceive why it should be more difficult to do "curve work" than with a chain 100 ft. long. It is as readily divided into halves and quarters without the use of more than one figure, and this length (20 m.) is also divisible by 5 and 10.

The objection to the level rod is also without foundation. The difficulty in readily determining the meters is wholly overcome by marking the meter in connection with the decimeters, that is to say, to mark the decimeters continuously from end to end instead of beginning anew with each meter. I have had several level rods made and marked in this manner, and with *ordinary* care it is impossible to make errors.

The rods are three meters long (and of course can be made longer if necessary or deemed advisable) and 5 centimeters wide and 2½ centimeters thick. They are divided into centimeters, being alternately white and black, and extending 2 centimeters across the face of the rod (from the edge), thus leaving 3 centimeters for the figures.

The accompanying sketch will show the arrangement more readily than any extended description. EMILE LOW.

SIZES OF SEWERS.

EDITOR ENGINEERING NEWS:

DEAR SIR: Can you give me any satisfactory formula for proportioning the sizes of sewers, when inclination and area are given? Have figured by Hawksley's formula, also by Roe, and there is a large difference. Figuring by Hawksley, and then figuring the amount of water to be taken per hour, I find that it does not agree at all with the size required to carry away the water.

S. C. T.

[In populous districts, and when the main sewer receives contributions at constant intervals throughout its length, and the rainfall is estimated at one inch per hour, Hawksley's formula is a safe one. Roe's tables, for he gives no formula, are entirely unreliable, and in England are not regarded as having any basis beyond an hypothesis of Mr. Roe. We would recommend, as in accordance with much experience, that when the rainfall is of very variable extent, the formula of Mr. Hering, given in ENGINEERING NEWS of Jan. 28, 1882, would be a safe guide. This will give the volume of water in cubic feet per second, and this applied in any of the established formulæ for water drainage, such as Downing or Beardmore, will give the diameter of a circular sewer capable of discharging that quantity.]

METRIC LEVELING RODS.

BOSTON, Feb. 27, 1882.

EDITOR ENGINEERING NEWS:

The great variety of designs that have been used for self-reading rods divided into feet and hundredths is almost entirely due to the diminutive size of the divisions of the foot. Even at moderate distances they cease to be easily distinguishable, and to adapt the rod to long distances recourse is had to various groupings of lines, and to the size, shape and position of numerical figures. These features, being entirely arbitrary, have led to the production of a great variety of combinations, no one of which has been extensively adopted.

The divisions of the meter being more than three times as large as the corresponding divisions of the foot, a metric leveling rod can be read at much greater distances. Their efficiency is, therefore, much less dependent upon any peculiar grouping of lines, or the position or shape of numerical figures, and a design based upon a few general principles will be more extensively adopted.

The variety of designs will consequently be less, and the makers of engineering instruments will take more interest in perfecting an article which promises a better demand.

An acceptable design for a metric leveling rod must be decimal in character, and must be based upon a consideration of the absolute size of the divisions of the meter and their adaptability to various classes of work. It should provide the assistance needed by the eye in counting its finer divisions, and its figures should be of sufficient size to be easily read at a distance.

According to the well-known principle that an approximate measurement, taken to the nearest unit, will not differ from an accurate measurement by more than one-half that unit, we may premise: Firstly, that approximate readings of the rod taken to the nearest *decimeter* will vary five centimeters, or less, from accurate readings. This degree of approximation is within the limit of accuracy required in preliminary surveys and reconnaissances, benches and turning-points excepted.

Secondly, that approximate readings taken to the nearest *centimeter*, will vary five millimeters, or less, from accurate ones. Such readings are, therefore, suitable for a very large portion of engineering work.

Thirdly, that readings taken to the nearest *millimeter* will be within half a millimeter of the greatest possible accuracy.

Now it may be easily ascertained by trial, that the unavoidable errors of observation incident to the process of leveling are at least of the same order of magnitude as the half-millimeter. They arise from the difficulty of maintaining the line of collimation strictly level during an observation, from the space covered by the thickness of the cross-hair, from imperceptible deviations of the rod from the vertical, and from various other causes. Readings taken to the nearest millimeter are, therefore, within the limits of accuracy attainable, and an attempt to work to fractions of the millimeter would be an unnecessary refinement.

A leveling rod suitable for all classes of work should, therefore, be distinctly marked in *decimeters* and *centimeters*.

Divisions into millimeters are not attempted on self-reading rods. Target rods, however, are provided with a short scale of millimeters, which takes the place of a vernier.

The millimeters are read from a self-reading rod by a mental subdivision of the centimeter blocks into ten equal parts. This may be done with surprising accuracy, and offers no special difficulty when the process of reasoning upon which it is based is well understood.

A division into ten equal parts admits of but five different combinations, viz., 1 and 9, 2 and 8, 3 and 7, 4 and 6, 5 and 5. If the cross hair falls near the end of the block it is called 1 or 9. If it cuts off a little less than one-fourth it is called 2 or 8. If it cuts off a little more than one-fourth it is called 3 or 7. If it is nearly in the middle it may be either 4 or 6; if exactly in the middle, 5. The number of cases being so very few a little practice will enable one to estimate tenths with great accuracy.

To assist the eye in counting the centimeters every fifth one should be distinctly marked to form a new point of departure.

The divisions may be painted in black or in vermilion, upon a white ground; or alternate meters may be in black and red. Black divisions form the strongest contrast for the white ground. Red divisions throw the cross-hair into stronger relief and are more easily seen among foliage. The figures should be black, invariably, with broad lines, hair lines being avoided. They should be at least 25 millimeters in height.

The figures indicating the meters should be repeated at every decimeter, forming, with the other figures, a continuous numbering in decimeters.

A rod thus marked will always present to the

(*Continued on Page 92.*)

ENGINEERING NEWS.

GEO. H. FROST.....PROPRIETOR.

Tribune Building, New York City.

JULIUS W. ADAMS, *Past President A. S. C. E.*, EDITOR.

S. D. V. BURR. .....ASSOCIATE EDITOR.

SATURDAY, MARCH 18, 1882.

EDITORIAL ANNOUNCEMENTS.

Terms of Subscription.—To the United States and Canada, $4 per annum, including postage; all parts of Europe, $5, payable in advance. Remittances at the risk of the subscriber, unless made by registered letter or by draft, check or P. O. order, payable to GEO. H. FROST.

Terms of Advertising.—One inch, 12 lines, one insertion, $2; one month, $6.50; three months, $17; six months, $30; one year, $50. Special rate for large space and long time will be given on application. Advertisements inserted for less than three months, payable in advance; for longer time, payable quarterly.

Articles for Publication in the current number should be received at the office of publication not later than Thursday morning, and advertisements not later than Friday noon.

Correspondence upon subjects which naturally belongs to the province of this journal is solicited.

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APPLIED MATHEMATICS.

In answer to a correspondent on the subject of the radius of gyration in another department of this issue, we take occasion to express our satisfaction at the opportunity which it offered of giving some hints to young America on the tendency of the "would-be scientist" to run riot in mathematical symbols, on the erroneous impression, that science consisted in "burying the most simple facts completely out of sight under heaps of mathematical rubbish." We are indebted for this last expression to an accomplished and well-known engineer, who, endeavoring to render his past experience of value to those who come after him, finds the necessity at times of dredging into this rubbish, and bringing to the light of day what of truth may lie hidden at the bottom.

On the other hand, we would deprecate as fraught with untold evil, the least of which is the money value wasted, the practice of engineering by individuals ignorant of the very foundation upon which all engineering science must rest—viz., mathematical truths; and we would particularly warn our young friends against adopting the views of the manager of the Hudson River Tunnel as shown in his testimony before the Coroner's jury, which we reprinted in our last issue under the head of "RULE-OF-THUMB ENGINEERING." And we note this instance with a view to impress upon our readers the distinction which we would draw between the *misuse* of the higher analysis in its application to every-day mechanical details, and the proper *use* of those mathematical principles which form the basis of all engineering operations.

In the preface to Prof. Rankine's "Applied Mechanics" (third edition), a writer who confessedly indulges in more "tangled" and needless exhibitions of elementary analysis of plain, practical, common-sense problems than almost any writer on mechanical subjects with which we are acquainted, yet expresses himself as follows, after referring to the importance at times of complex algebraical investigations: "But in expounding a proposition as a part of practical science, and applying it to practical purposes, simplicity is of the first importance; and in fact, the more thoroughly a scientific man has studied the higher mathematics, the more fully does he become aware of this truth, and I may add, the better qualified does he become to free the exposition and application of scientific principles from mathematical intricacy."

Notwithstanding this very sensible annunciation in favor of simplicity, it has never been our pleasure to see anything of Professor Rankine's which was not more or less obscured by a jugglery of mathematical symbols, wholly uncalled for by the nature of the subject treated, and tending to complicate what in itself was sufficiently simple. And in an acquaintance with engineers, who all speak of Rankine with respect, we rarely have met one who was ready to acknowledge that he has derived any practical advantage whatever from his method of investigations. And in our experience of nearly half a century as an engineer we have very rarely found that engineers possessing this peculiar facility of minute mathematical analysis with the consequent reliance upon its infallibility which usually accompanies it, were safe guides, either in the design or the execution of novel projects.

Recognizing Rankine as a master of analysis, weak minds have been led through his example, and as an evidence of scientific ability on their own part, to confound facility for putting into complex mathematical relations facts and figures with methods which readily admit of simpler treatment.

Now, the higher analysis is an exact science, and were the concrete matters dealt with in applied mechanics equally exact or certain in their values, there would be no objection to this method; but we are dealing practically with imperfect materials; how imperfect, and in what direction, we know not precisely, but after pursuing the methods of the calculus based upon presumed homogeneousness of material, the fallacy of the process for practical purposes is recognized, and varying coefficients and factors of safety, according to the judgment of the engineer, are finally of necessity introduced, in order to render the result of any practical value. Hence the absurdity of looking in the clouds with a telescope of high power in search of facts within our grasp on the surface of the earth.

As an illustration, having had occasion lately to investigate the subject of high masonry dams, we turned to one of Van Nostrand's science series treating of the subject for such light as might be had, and after following several pages of elaborate calculation in which all the resources of the calculus were exhausted, and which undoubtedly exhibit the author's mathematical skill, whatever may be said of his judgment, we finally, in search of the proper profile of the dam, arrive at two equations, of which the author remarks as follows: "Here a new difficulty presents itself, for no sooner do we attempt to integrate equations 34 and 35 than we see it is quite impossible to perform the integration by any exact method." Attempting the solution, however, by a method of approximation credited to Mr. Delocre, he arrives at two equations, of which he remarks: "These equations, it is quite apparent, are of no earthly value for practical purposes, and we shall drop all further consideration of them," and adds: "Indeed, if it were possible to obtain the equations of the curve by a short and simple process of integration, a moment's reflection will show that such a profile would not be suitable for practical use." Continuing our search for truth, we found that Mr. Delocre had written an exhaustive treatise on the subject of high dams in a memoir published in the "Annales des Ponts et Chaussées de 1866," and referred to in the "Manuel de l'Ingenieur des Ponts et Chaussées," by A. A. Beauve, translated by E. Sherman Gould, Assistant Engineer Croton Aqueduct, New York, in the following words: "There is no difficulty in establishing the differential equations of the resistance of reservoir dams, but their integration has not been effected; they therefore possess no practical interest. They may be found in the work of M. Delocre," and finally recommends as of more practical value a calculation based upon graphical construction. Now it would appear from the above that, seeking a result founded upon abstract truths, it was not until the calculation was complete that it was discovered that after exhausting the powers of the calculus ineffectively, recourse was finally to be had of necessity to a simpler method before a tangible result could be reached. If the teachers of applied mathematics would but follow Professor Rankine's advice as given above, and not his practice, we would not be disposed to question their skill as teachers, but the pursuit of abstract, pure mathematics as an end in itself is so seductive that its legitimate application toward enlightening the many is too frequently lost sight of by its admirers.

Now it would be absured to question the value of the differential and integral calculus, for as one of its historians remarks, alluding to the kindred methods of fluxions, "it is one of the greatest, most subtle and sublime discoveries of this or perhaps of any age, opening a new world to us, and extending our knowledge, as it were, to infinity, and carrying us beyond the bounds that seemed to have been prescribed to the human mind."

While there are some problems of practical value, the solution of which cannot be reached but by the use of the calculus, there are many others where the claim to mathematical accuracy growing out of the mere use of this method, irrespective of the data upon which it may have operated, is a pure assumption and a confounding of mathematical adroitness in the compilation and transformation of formula with science. Mathematics is merely the symbolic language, so to speak, through which the truths of science in their relations, one to the other, may be expressed.

For instance, operating by the established mathematical rules upon imperfect or false data, however skillfully conducted the process may be so far as the mathematician is concerned, the result is not science, although the process may be what is called scientific.

The whole gist of this question of misapplied mathematical skill is well shown in one of "Prof. Huxley's lay sermons," and we beg leave to commend its perusal to our would-be mathematical scientists.

"Mathematics," he says, "may be compared to a mill of exquisite workmanship which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends upon what you put in; and as the grandest mill in the world will not extract wheat flour from peascods, so pages of formula will not get a definite result out of loose data." We are well aware of the kind of criticism to which we lay ourselves open by questioning the universal applicability of the integral calculus, viz.: "That we are probably completely ignorant of its uses." Two years, at least, of our student life was expended in its study under the instruction of a mathematical teacher and author. Whatever may have been our progress, so soon as the applied mathematics came within our daily professional practice, we found so slight a need for the exercise of the calculus that its continued disuse left little in our memory beyond its nomenclature. The differential calculus is that branch of analysis whose object is to determine the limit of the ratio of the increment of any function to the increment of the variable; the term function of a variable being applicable to any quantity dependent upon that variable for its value. The integral calculus, on the contrary, has for its object the determination of the primitive function, from which a given differential expression has been derived. Together, they constitute what we call the calculus, well suited to exercise the analytical faculty of mathematical students; and something more than its elements, merely, should be mastered by all teachers and professors of mathematics and theoretical engineering; but its continued study in practical life (and without this study its proper use is impossible) is not conducive to the successful practice of engineering, save in rare instances for reasons previously hinted at.

The doctrine of fluxions, in use from the time of Newton, and which differs from the more modern differential calculus, but in its nomenclature (a fluent being the same as the function in the calculus, and a fluxion the equivalent of its differential coefficient) was referred to by Tredgold in the preface of his treatise on cast iron, republished by Hodgkinson in 1842. Tredgold was a writer of eminence on many branches of physics, and exhibited very high mathematical attainments in the demonstration of his various investigations, and was never open to the charge of ignorance of any subject whereof he wrote. While we cannot say that we carry our objections to the use of the calculus in applied mathematics to the same extent as this writer has done we doubt not that the reliance which we have been taught to place on his writings shaped themselves into an assent at least to the non-essential value of the calculus to the practical engineer.

We close with a quotation from the preface referred to:

"I have avoided fluxions in the investigation of these rules in consequence of the very obscure manner in which its principles have been explained by the writers I have consulted on the subject. I cannot reconcile the idea of one of the terms of a proportion vanishing for the purpose of obtaining a correct result. It is not, it cannot be good reasoning, though, from other principles, I am aware that the conclusions attained are accurate. If the doctrine of fluxions be freed from the obscure terms, limiting ratios, evanescent increments and decrements, etc., it is really not difficult. If you represent the increase of a variable quantity by a progression, any term of that progression (except the last) corresponds with what is called a fluxion; and the sum of the progression is the same as a fluent. A fluxion is, therefore, the velocity of increase of an increasing quantity, a decrease of a decreasing one, on the supposition that we take the velocity at any point and consider it uniform. But when you use this uniform velocity to represent an accelerated one and say that the ratio of these velocities approaches to a ratio of equality as its limit, while the space or time of description is diminishing to evanescence, I must be allowed to withhold my assent to your doctrine. For it is clear that the exact ratio of equality can attain only when the space described is nothing, and consequently it cannot, with logical accuracy, be employed to compare the spaces generated when they become of finite magnitude."

THE OUTLOOK FOR ENGINEERS.

The careful attention of those engineers and contractors who are placing their main hopes for employment during the coming season, on railroad building is invited to the reported interview with Mr. Russell Sage, one of the leading railway magnates of the country, which will be found in another column of this week's ENGINEERING NEWS, Mr. Sage asserts that there will be a great falling off in railway construction this year, and the activity of the past two years may perhaps not be resumed for some time to come. Mr. Sage is one of the leading speculators in Wall street, a region that hatches more unreliable information than perhaps any other spot of equal area in the habitable world, and so whatever Mr. Sage says on matters that deal directly with the rise and fall of stocks may naturally be received with some grains of allowance for the influences surrounding him. But it is probable that he tells enough truth to warrant the thoughtful consideration of those men who are patiently awaiting the time when active operations in railroading will be resumed, and who if warned in time would turn their attention elsewhere to their own advantage and to that of those who cannot change at once without very serious damage. By thinning the ranks of competition fair profits may continue to be made, while those who enter other fields will not suffer. But where shall the "left" ones look for business? First, if it could be succesfully accomplished, the "incompetents" should be weeded out, and obliged to go into other and, probably, more profitable occupations; if any that remain are tempted to try land surveying, we advise them to abandon such an evidence of mild insanity, and turn their muscle, if not their brains, to more profit; in the larger cities the Engineering department is usually well stocked, and the politicians keep faithful watch and ward over it, lest perchance an occasional vacancy should occur; do not waste time and energy upon such well tilled ground. We confess we hardly know where to point the way to aspiring engineers, except they are themselves prepared to do considerable original investigating, and if necessary, "tramp" it in search of opportunities. Foreign engineers, notably the English, are the promoters of nearly all public works; they do the "prospecting," discover the opportunity, "work up" the scheme, form the constructing companies, and with the aid of the solicitors, carry the scheme through the necessary legislation, and then, if further progress is deemed advisable they construct the works. But we never hear of an American engineer "promoting" any public work. Instead, it is done by some shrewd man who sees, or fancies he does, "millions in it," and all the part the engineer plays in the scheme is to make a few surveys at so much per diem to get data to work from, and then if the matter succeeds he gets possibly a few months' further employment at the lowest price his services can be engaged for. If there is profit in the venture he fingers no portion of it, and in a few months he is forgotten, until, perchance, his former patrons may have discovered something else for which they need the use of his brains and skill for another short while. From this plan of professional action scarcely any notably prominent engineers arise as may be found in England, where large incomes are enjoyed by a great many engineers, some of whom have world-wide reputations, and have won their way to special distinction by their sovereign. This country never was in a more prosperous condition than at present; money abounds, and, as a usual thing, the people are not afraid to spend it. There are States in the North, like Vermont and New Hampshire, where agriculture being the leading industry, and the principle of being careful of the small change having permeated the whole body politic, there are no large public works likely to be undertaken, and it is but a waste of railway fares and hotel bills to journey in that direction. Only native born and bred engineers can hope for even a small measure of success thereabouts. Again, in the South there is a remarkable dearth of large towns and cities; money is not as abundant as is desirable, and while the conditions are yearly growing more favorable, our engineer must pay out a "good bit" in traveling expenses, and subject his stomach to a very severe course of dieting before he will find an eligible location to practice his profession in with profit. But there *are* opportunities in the Southern States that will repay the investment of time and money and brains necessary to develop them. It is a magnificent country and it is inevitable that it must make very great progress within the next decade. But there are hundreds of considerable towns demanding better water supply and sewerage and paving, and for the engineers who will go to the expense and labor of "prospecting" for them we are quite certain that a large and profitable field awaits their cultivation. There is also more bridge building to be done at present than there are companies to do the work, and whatever may be said about competition and low prices, it is noteworthy that there are very few financial failures in the bridge-building business. There is a vast area of country between the Atlantic and Pacific to be developed and improved for the use of its ever and rapidly-growing population, and while there may be temporary lulls in engineering activity, yet there must always be a fair proportion of remunerative business for the men who are alert and who care to keep sufficiently posted as to the shifting scenes of activity in their profession. But we feel convinced that a considerable advance will be made when engineers assume the leadership in promoting public work, instead of simply "sitting in the market-place" like common laborers "waiting for a job."

SPIRAL CURVES.

We would not discourage the study of such subjects as comprise the contribution under the above heading in No. 10 of ENGINEERING NEWS. The writer has treated it with ability, and shown a painstaking desire to perform accurate work, and we should have spared any question of its practical value had it been a mere office exercise; but from the statement that "on the road 30 meter spirals are being laid out by locating parties as well as for track centers," it appears that the engineer is muddling the heads of his assistants with refinements of location, when their time could better be employed in some study of practical value to them in their future career. We venture to say that laying off such a curve as he has illustrated from one tangent point, with such instruments as are to be found on most railroads, and then laying off the same curve from the other tangent point, there could be no possible agreement between the points made unless by a system of repetition and some elimination, which means loss of time and patience on the part of operatives. If this were attended with a possible benefit, it would be well, but let us assure "Young America" that it has no practical value whatever, and tends to bring into discredit much of his labor which is of positive value. It is desirable, it is true, to connect the tangents on a line of road, by curves of as long radius as the location and nature of the ground will permit for mechanical reasons in the nature of the machinery used, and it is also desirable to reduce the shock occasioned by passing at high speed from a tangent to a curve to a minimum. But within limits the expenditure of power at a given speed in a change of direction of a certain number of degrees of arc is the same whatever may be the radius of curvature. If there were in nature some principle by which bodies tended to move in curves, this might possibly be otherwise, but as things are the curved motion is the resultant of forces tending to move in straight lines, and practically no body in motion on a railroad track is *coaxed* into a total change of direction with the expenditure of less power by gradually increasing the increments of change from a minimum to the maximum.

We have ourselves been in this same boat. In the "Curve of Construction," written by Sganzin, "Inspector Général des Ponts et Chaus ées," the text-book of many years ago, it is recommended that changes of directions of roads should be made by parabolic curves, and gives as a reason, that "the extent of curvature of such curves decreases as we pass from the summit of the curve, and consequently the passage from the straight line to the curve is less sensibly felt." We have here the principle of the spiral curve, as we understand it. Full of the importance of the labor, we laid off such curves, not on location lines, but in laying the track. Revisiting the locality some years afterwards, we found, as might have been expected, that what with settlement of road-bed by effect of frost and otherwise; the track repairers had wholly disregarded our refinements of line, and laughed, as they well might, at parabolic curves. This easement at the point of tangency, as it is called, as also between adverse grades by vertical curves, can well be left, where it always will be exercised, to the eye of the skillful track-man, with his straight-edge and crow-bar.

PERSONAL.

Mr. Thomas H. Tracy has been appointed City Engineer of London, Ont.

THOMAS HANFORD SMITH, who died suddenly of apoplexy on the 16th, at his residence, 443 West Twenty-second street, this city, was the builder of the Boston Cathedral, St. James' Church, Boston; the West Twenty-third Street Presbyterian Church, the Madison Avenue Reformed Episcopal Church, the Metropolitan Life Insurance Company's building, the Foundling Hospital in Sixty-seventh street, and the New York Bar Association's building. He was born in Rye in 1812, and had been in business in this city 48 years.

MR. NORMAN STRATTON, civil engineer, United States Navy, died suddenly of heart disease on the 10th at his residence No. 242 DeKalb avenue, Brooklyn, in his sixty-third year. Mr. Stratton was born in Stillwater, Saratoga County, this State, graduated from the Rensselaer Polytechnic Institute, Troy, and subsequently from the Albany Law School. He was civil engineer of the first railroad constructed from Albany to Schenectady. He afterward practiced law in this city for 17 years. About 11 years ago he was appointed civil engineer in the United States navy. In 1878 he was run over and seriously injured by a carriage. His health subsequently failed, and last fall his name was placed on the retired list.

RECENT INVENTIONS.

A novel ditching machine or excavator has an inclined auger secured within the frame or body of the machine for excavating and elevating the earth, the cutting edges of which turn in a semi-circular groove formed in a block attached to the under side of said frame. The arrangement of this groove is such as to cause the excavated earth to rise to the outlet, whence it falls on stationary inclined planes, that direct it to the sides of the ditch.

Another late invention in excavators has an excavating wheel which turns in a vertically-adjustable swinging frame journaled on the engine driving shaft, and is driven by a chain from such driving shaft, which operates a pinion meshing with an internal gear on the wheel. An inclined shelf and vertically-adjustable shield are carried by the frame, whereby the dirt is directed to one side, and prevented from falling from the buckets while being elevated. The machine is fed forward through a sprocket wheel and chain driven from the engine, and is capable of being worked with or independent of the wheel-driving mechanism. Stationary side plates protect the internal gear.

An interesting improvement in bridge gates for draw-bridges consists in operating the gates at either end of the draw, by pneumatic pressure controlled by the bridge attendant through suitable mechanism on the draw-bridge. The gates slide in vertical guides on the abutments, and air cylinders, with tight-working pistons connecting with the gates, are located in the abutments beneath the gates. On the pier upon which the draw span revolves are arranged suitable air-compressing mechanism, having pipes leading therefrom, along the bed of the channel to the before-mentioned operating air-cylinders.

A late improvement in steam boilers combines with the grate and hollow side walls of such boiler a series of side pipes for conveying the products of combustion, and a series of steam pipes communicating with such side pipes, at or near the discharge orifices, whereby the products of combustion are drawn back and discharged into the fire.

A novel stock or cattle car has a feed bin arranged beneath the roof of the car, and extending the length thereof. This feed bin has its bottom wall constructed with openings, governed by valves adapted to be simultaneously operated. Adjustable troughs are suspended beneath said bins adapted to be secured at any desired elevation. A water tank is also located on the roof of the car with pipes leading throughout the car to suitable drinking receptacles. The pipes have appropriate stop-cocks.

A new dredge-dipper consists of a two-part dipper-bottom, the lower front section being secured by an adjustable catch, and pivoted to the opposite sides of the dipper. The other or top section is capable of swinging in as well as out, and when loaded rests against the upper edge of the lower section. The arms of the bottom section are pivoted to raised seats upon the side straps, to which are secured handle-braces. This improvement is designed for use in connection with a steam-dredging apparatus.

A late invention consists of an electric meter comprising a clock work mechanism having an escapement governed by a pendulum or balance of magnetic metal, in connection with an electro-magnet, the poles of which are arranged to determine the movements or oscillations of the pendulum or balance. This magnet is arranged in the electrical circuit, through which the current is to be measured.

A novel apparatus for superheating steam, designed particularly for locomotive boilers, consists of the steam pipe, which is arranged to pass through the roof of the fire-box, extending horizontally therein, and thence repassing through the roof of said fire-box and connecting with the cylinders of the engine. A tube incloses that part of the steam-pipe located within the fire-box to create an intervening water space between the two, said tube having its ends secured in the roof of the fire-box, and in communication with the water space of the steam boiler.

F. B. BROCK.

WASHINGTON, D. C.

THE CHECK TO RAILROAD BUILDING.

When asked for his opinion of the present condition of railroad business and the prospects of the companies, Russell Sage said to a reporter:

"The present inability of promoters of railroad enterprises to go on, being checked by their failure to negotiate bonds and stocks to secure the money to prosecute the work of construction, leaves the older and already finished roads in a better condition than would be possible if the mania for building new roads were to continue."

"Then you consider the construction of new roads practically at a standstill for the present?"

"Few railroads will be built this year. There is a general suspension of this work all over the country. I am connected with a dozen of these corporations, and in each instance we have wound up the work for the present, after settling with the different contractors. I do not think they will go on again for a year or two; perhaps it will be even longer. I am ready to go on when I am satisfied that it will pay; but I am unalterably opposed to building a mile of railroad when the business will not fully justify it. There is an unerring law of progress, that fully one-half of all the new railroad enterprises are swept away, and another set of proprietors comes in to take their places. The history of three-fourths of the roads built in the United States shows that the original promoters of new roads have to sell out for one-half, or less, of their investment. A necessary result of the present suspension in the construction of new roads will be that investors will take the stocks of the finished and already paying roads at better prices than have recently prevailed."

"To what causes do you attribute the recent downward tendency of all railroad stocks?"

"It is well known that we had a pretty full head of speculative steam on previous to the assassination of President Garfield last July. That caused the first check. From the 2d of July on, down to the beginning of the present year, there has been a steady decline, with the usual fluctuations. These fluctuations have been owing, in part, to over speculation and over construction of new railroads; the general decline was accelerated by the short crops and damaging freshets beginning early in October, running through that month and November. When we reached the beginning of the new year, financial troubles broke out in France and spread all over Europe. The rates of interest rose from 2½ to 8 and 10 per cent., which was very excessive for such old and conservative countries as France, England, Austria, Germany and Holland, the money centres of the world. Of course, in that panic heavy losses followed, and enormous damage was done. These troubles in Europe contributed to our depression by sending back a good many of our stocks and bonds and throwing them on our market at a time when there was a decreased demand. The bears took advantage of this state of affairs to magnify and misrepresent the real condition of the country."

"How do you regard the improved tone of the market within the last few days?" asked the reporter.

"The country at large is very rich, and investors are well able to take securities at the lower rates which are now ruling. I regard the condition of things as assuming a very healthy outlook for the future. Prices are such as now to justify the most conservative capitalist in making investments. Money is plenty and the continual paying off of the National debt throws an almost unprecedented amount of additional money into the market to be invested. The recent change of tone on the street will do a vast amount of good to people who, having originated wholesome enterprises, will now be enabled to go on. This change of tone will be more beneficial to the business interests than anything that could have happened. Otherwise many legitimate and desirable enterprises must have suspended, owing to fear that we were drifting toward—not a panic—but general dullness and depression. I think that Mr. Gould and Mr. Vanderbilt, in coming forward and planting themselves down solid for the right, have restored a feeling of confidence which was very much needed, and which will produce very beneficial results. With such crops as we may reasonably expect, and with the unexampled prosperity of the past ten years going steadily on, I shall be surprised if by September and October a general change of such a character is not shown as to prove how the wicked 'bears' have misled the public in trying to make it believe that ruin was close at hand.

"Another view to be taken of this depression, and one which makes it clear that it has not been without profit, is that it has checked extravagance and the growing importation of high-priced luxuries from abroad. The importation of these goods has materially fallen off, much to the gratification of thoughtful people who watch the balance of trade, which should continue in our favor. In view of all these facts, I am strengthened in the conviction that we have turned the corner in this downward career of the market, and that from this time on the advance will be continuous on all completed roads that deserve it."

ENGINEERS' SOCIETIES.

ENGINEERS' CLUB OF PHILADELPHIA.

ROOMS, No. 1523 CHESTNUT ST., PHILADELPHIA, Pa.

Record of Regular Meeting, March 4, 1882.

President Rudolph Hering in the Chair. Twenty-five members and one visitor present.

The Secretary presented, on behalf of Mr. Thos. U. Walter, Honorary Member, a description of his experiments in 1836-7, upon the effect of extreme temperatures upon iron bands imbedded in the walls of Girard College, Philadelphia, of which he was the architect. These bands, each 54 ft. long, were introduced to resist the lateral pressure of the arches. Although confident that no evil could result therefrom, Mr. Walter considered the positive evidence of these experiments both satisfactory and interesting. The south vestibule wall, 5 ft. 5 in. thick, subjected to the full power of the sun during summer and in winter under temporary roof, with no fires in furnaces, was selected for experiment. Self-registering thermometers, minimum for winter and maximum for summer experiment, were placed upon the band and the whole walled in as finished work. The following changes in Fahrenheit degrees took place:

Sept. 23, 1836.	82°	Intermediate extreme cold—3°.
July 20, 1837.	85°	Minimum temperature in middle of wall, 42°.
Jan. 16, 1837.	24°	Intermediate extreme heat, 94°.
Dec. 16, 1837.	27°	Maximum temperature in middle of wall, 61°.

Difference of temperature outside of wall, 97°. Difference of temperature in middle of wall, 19°.

Smeaton's co-efficient of expansion for malleable iron, $\frac{1}{784}$ of length for 180°, being somewhat greater than that of other experimenters, was used. The co-efficient for brickwork, $\frac{1}{118}$ of length for 180°, was taken from experiments by A. J. Adie, C. E., (Royal Society of Edinburgh, April 20, 1835).

The difference occasioned by a change of 19° in temperature in a length of 54' is, therefore, less than $\frac{1}{16}''$, but if we consider that the exterior of the wall is subjected to the extremes of heat and cold, it will be obvious that the aggregate change of the brickwork is even greater than that of the iron.

Mr. Geo. P. Bland read a paper upon the practical strength of wrought-iron columns, giving formula and diagram, and arguing that the factor of safety should be established with reference to the limit of elasticity.

Mr. Howard Constable exhibited a blue copy of the Kinzua Viaduct, and stated that its height will be 300' and length 2,000'.

Mr. Henry G. Morris described the Hotchkiss mechanical boiler cleaner, which consists of a spherical cast-iron vessel placed above the boiler, which it enters by a vertical flow pipe bent 9° just below low-water line and opening there in funnel form; also by a return pipe carried nearly to the bottom of the boiler. The sediment, rising invariably to the surface before being deposited on the bottom or flues, is carried into the funnel by the circulation of the water from front to rear of boiler, and reaches the spherical vessel, where it is deposited; the water returning to the boiler by natural circulation. The sediment is removed from the cleaner by opening the valve in a pipe connected with the bottom thereof, after closing the valves in the flow and return pipes.

The Secretary presented a paper by Mr. P. H. Baermann upon "What thickness of metal should be given to cast-iron pipes under pressure?" The various formulæ are reduced to the same notation, classified and compared, and illustrated by numerous diagrams. The quality of iron, practical difficulties in casting, minimum strength required for handling, the static head, force of ram and of rapid closing of gates or hydrants and allowance for deterioration, are considered at length. A table of one-fifth ultimate strengths is given. One of the main facts derived from the comparison is, that the thicknesses, obtained from the formulæ, give pipes of varying strength when calculated for a given head, and that the least thickness, necessary to cover imperfections in casting and for safe handling, is ample for pipes of small diameters under all ordinary heads.

HOWARD MURPHY,
Secretary and Treasurer.

AMERICAN SOCIETY OF CIVIL ENGINEERS, 127 EAST TWENTY-THIRD STREET, NEW YORK.

March 15, 1882.—The Society met at 8 p. m., President Ashbel Welch in the chair.

The death of Gen. W. W. Wright, member of the Society, in Philadelphia, March 9, 1882, was announced.

A paper by Mr. E. H. Keating, City Engineer of Halifax, was read by the Secretary. The paper described the results of the mechanical removal of incrustations from the water pipes of that city.

These incrustations had become so serious as to reduce the pressure so that in many places water would not flow from the street hydrants. In some pipes the deposit was over 1½ in. in thickness. Six-in. pipes were found reduced to an internal diameter of 3¼ in. to 3½ in.

In the years 1875 and 1876 a number of miles of old 3-in. pipes were cleaned by a scraper attached to iron rods and propelled by hand. The scraper had 4 arms or knives attached to a center, and sprung outward by a thick rubber disk. This method was not practically applicable to pipes of large diameter; but in 1880 over a mile of 12-in. pipe was cleaned by a scraper forced through the whole length by the head of water in the pipe. This scraper was one imported from Scotland, and its work was fairly successful.

In 1881 the author of the paper constructed new scraping machines which differed from the others in having additional springs for the cutters and the pistons. These scrapers consist of an iron rod to which are attached two pistons and two sets of cutting tools, one in front of the other. The cutters are each made up of four strips of steel 2½ in. broad, sloping backwards from the rod and at their outer termination shaped and sharpened like the barbs of an arrow. Thus they can yield when requisite and the cutting diameter can be altered by moving the steel strips. The pistons are of iron, lead and leather, to which Mr. Keating adds rubber springs. With this apparatus and with the ordinary head in the pipes about 12 miles of 24, 20, 15 and 12-in. pipes were cleaned at a total cost of $2\frac{3}{16}$ cents per foot. The results were remarkably satisfactory, as is shown by the fact that the average pressure on 25 hydrants on the wharves increased from $34\frac{3}{16}$ lbs. in February, 1880, to $52\frac{4}{16}$ lbs. in February, 1882. These were on the low service, the source of which is 4 miles from the city and 200 ft. above tide. On the high service, the source being 8 miles from the city and 360 ft. above tide, there is now a pressure of 19 lbs. per inch at hydrants where the water did not flow at all.

Some remarks were made on the overflow of the Mississippi River by Mr. Lyman Bridges, Member Am. Soc. C. E. The area of the water-shed of that river is 1,147,000 square miles, with an annual rainfall of 80,000,000,000,000 cubic feet and a drainage of 20,000,000,000,000 cubic feet. This is inclusive of the Red River basin. The principal levees are below the Red River. The mean annual amount of sediment passing the mouth of Red River is given by Humphreys and Abbott as 812,500,000,000 tons. The deposit of this at certain points is a source of constant danger. Levees are raised continually; but great floods, as at this time, frequently occur. The speaker suggested, as a measure of relief, the improvement of the old channel near the mouth of Red River, the improvement of the Atchafalaya and its parallel bayous, a connection with the Mississippi at Plaquemine, and the improvement of the outlet to Atchafalaya Bay. This would give a flood outlet one half the present length of the river from the mouth of Red River, and one-quarter the length from Plaquemine, through which 33 per cent. of the present flow could well be carried.

The necessity of complete surveys of the Mississippi were forcibly presented.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E.

Continued from page 84.

CCXXXIX.—NEW BRIGHTON, N. Y.

New Brighton, New York, in lat. 40° 38' N., long. 74° 1' W., is on Staten Island, on the shore of the Kill von Kull, on ground rising in terraces from the water's edge. It is occupied principally for suburban residences of persons doing business in New York City. Water-works were built in 1881, by John Lockwood, for a private company, W. J. McAlpine, C. E., being the consulting engineer. Water is taken from three 6-in. tubular wells, sunk 30 ft. in a sand and gravel stratum below the sea level, at the mouth of a ravine and small stream. A Knowles' compound condensing pumping engine, of 1,000,000 gallons capacity, lifts the water 210 ft. into a reservoir formed by a dam across a ravine.

Distribution is by 15 miles of cast-iron pipe, of 10-in. to 4-in. diameter, with 150 fire hydrants, 46 gates and 250 taps. Ten meters are in use. Service pipes are of wrought iron—some plain and some galvanized. The town pays $40 per year each for hydrants.

The population accommodated is about 13,500, and the daily consumption is reported as 500,000 gallons.

The capital stock of the company is $200,000,

and there is a bonded debt of $100,000 at 6 per cent. interest.

Further financial statistics are not furnished.

A. J. Hamilton is Secretary, and John Ward Superintendent.

CCXL.—POTTSTOWN.

Pottstown, Pennsylvania, in lat. 40° 15′ N., long. 75° 35′ W., is on the Schuylkill River, about 50 miles from its source. Settled in 1730, it was incorporated as a city in 1812.

Water-works were built by a private company in 1870 after the plans of Isaac S. Cassin, C. E., taking the supply from the Schuylkill, and pumping it by a Worthington pumping-engine into a reservoir 140 ft. above the river and 100 ft. above the town, with a capacity of 1,500,000 gallons at 17 ft. deep. Another pump is now building. Distribution is by cast-iron pipe of from 10 to 4-in. diameter, of which 7½ miles are laid, with 40 fire hydrants and 1,000 taps. A few meters are used. Service pipes are of lead. The City pays $500 per year for fire hydrants.

The population in 1880 was 7,214, and the daily consumption 135,000 gallons.

The capital stock of the company is $60,000. The works have cost to the present time $85,313.69. The bonded debt is $17,000. The expenses in 1880 were $3,971.78, and the receipts $7,451.23.

Mark H. Richards is President, and Joseph E. Yeager Superintendent of the Pottstown Gas & Water Company.

CCXLI.—WEST TROY.

West Troy, New York, in lat. 42° 45′ N., long. 73° 37′ W., is on the west bank of the Hudson River, on the bottom lands extending back nearly a mile to a slight elevation. The Watervliet U. S. Arsenal, established in 1807, is in the village, which was incorporated in 1836.

Water-works were built by a private company in 1876, after the plans and under the superintendence of Palmer H. Baerman, C. E., taking the supply from the Mohawk River, five miles from the village.

A dam 1,200 ft. long across the Mohawk gives a head of 7 ft., used for driving a 75-in. turbine wheel, which works a double-acting Flanders pump of 1,500,000 gallons capacity, which lifts the water 190 ft. to a chamber half a mile distant, whence it flows by gravity 5 miles to a reservoir built in excavation near the village and 180 ft. above it, and holding 70,000,000 gallons.

The force main and the conduit where crossing valleys are of 12-in. cast-iron pipe. The conduit, where laid on the hydraulic grade line, is a 15-in. oval cement pipe. Distribution is by wrought-iron and cement pipe, of which 12 miles are laid in West Troy. For the adjoining village of Green Island, which is supplied from these works, 3 miles of cast-iron pipe have been laid. The mains are from 16-in. to 4-in. diameter, and there are 90 fire hydrants and 350 taps. The village pays $10,000 per year for use of hydrants, with the right to require 100 to be set, in all. Lead and wrought-iron service pipes are used.

The capital stock of the company is $100,000. The bonded debt is $150,000 at 7 per cent. interest, and $20,000 at 6 per cent. The cost of the works has been $250,000. The expenses in 1881 were $18,000, including interest and taxes, and the receipts are reported as the same amount.

George P. Meneely is the President, and George M. Wiswall, Secretary, Treasurer and Superintendent.

CCXLII.—MELROSE.

Melrose, Massachusetts, in lat. 42° 27′ N., long. 71° 4′ W., is in a valley surrounded by hills. Settled about 1650, it was incorporated as a town in 1850. Water-works were built for the town in 1870 by George H. Norman. The supply is taken from Spot Pond, so named by Gov. Winthrop when he discovered it in 1632 and saw "divers small rocks standing up here and there in it." It covers 296 acres, drains 1.72 square miles, and is used also for supplying Medford and Malden. Its surface is 143 ft. above the village. A 16-in. wrought-iron and cement pipe conveys the water from the pond for 7,170 ft., and then is continued of 12-in. diameter for 893 ft. This pipe is owned jointly by Melrose and Malden.

Distribution is by 16.3 miles of 6-in., 4-in. and 2-in. pipe of wrought iron and cement, with 89 fire hydrants, 92 gates and 1,006 taps. Service pipes are of enameled iron. The town contributes from taxation $2,000 annually for fire hydrants and water used in public buildings and $1,500 for maintenance.

The population in 1880 was 4,443. The consumption is not known.

The works have cost for construction to Jan., 1882, $176,987.41. The total receipts from water rates from 1870 to 1882 have been $86,981.61. The bonded debt is $150,000 at 6 per cent. interest.

The expenses in 1881 were for maintenance $2,849.62 and for interest $9,000. The receipts were $14,548. The works are managed by three commissioners elected by the town. Addison Lane has been the Superintendent since 1871.

CCXLIII.—YORK.

York, Pennsylvania, in lat. 39° 58′ N., long. 76° 43′ W., is on both sides of Codorous Creek, in an undulating country. It was settled in 1720. Water-works were built by a private company in 1816, taking the supply from springs and conducting it into a small reservoir. Most of the supply is now taken from the creek and pumped 90 ft. into two reservoirs 15 ft. above the highest part of the town. The first pump was built by Birkinbine. A Worthington pump was put in later. Distribution is by 10 miles of cast-iron pipe of 10-in. to 2-in. diameter, with 50 fire hydrants, 34 gates and 1,500 taps. Service pipes are of lead. Water is furnished free for fire and public buildings. The population in 1880 was 13,940. The consumption is not stated.

The capital stock of the company was at first $10,500, which has been increased from time to time to $100,000. There is no debt. Further financial statements are not given.

Samuel Small is President of the Company and Jacob L. Kuehn the Superintendent.

CCXLIV.—LYONS, N. Y.

Lyons, New York, in lat. 43° 4′ N.; long. 77° 3′ Wis., on the Clyde River and Erie Canal.

It was settled early in the present century.

Water-works were built by M. V. B. Rowley in 1877 for three persons as a private enterprise, taking the supply from a large well fed by springs, and lifting it 20 ft., by a double force pump driven by a windmill, into a reservoir 1,200 ft. distant, holding 12,000 gallons and situated from 70 to 100 ft. above the village. Distribution is by 1¼ miles of cast-iron pipe of from 6-in. to 2-in. diameter, with 100 taps. There are no fire hydrants, the supply being for domestic use only. Iron service pipes are used. The population is 4,200. The consumption is not known. The works cost $4,000. The receipts are about $400 annually.

M. V. B. Rowley is the Manager.

CCXLV.—ST. CHARLES.

St. Charles, Missouri, in lat. 38° 48′ N., long. 90° 28′ W., is on the Missouri River. The city extends along the river bank, the business portion being on a plateau about 15 ft. above high-water mark, and 400 to 500 ft. wide. Back of this the ground rises about 200 ft. in 1½ miles. The difference between high and low water is about 40 ft.

The town was settled about 1760 by the French. It was the capital of the State when admitted to the Union in 1821. Water-works were built in 1881, by Carroll E. Gray, for a private company, after plans of Charles A. Smith, C. E., and under superintendence of J. T. Jones, C. E. The supply is taken from the Missouri River. In mid-river there is an abrupt step-off in the rock bottom. On this, at 8 ft. below low water, a 12-in. perforated wrought-iron pipe is laid, continued for 200 ft. with a flanged wrought-iron pipe, and then for 600 ft. with cast-iron pipe to a pump well of masonry, 25 ft. square and 30 ft. deep from the surface of the bank. A Knowles Cornish pump, of 2,000,000 gallons capacity, the steam cylinder being at the top of well and the pump at the bottom, pumps the water into two plate-iron settling tanks, each 70 ft. in diameter and 15 ft. deep, set on a masonry bed, 80 by 160 ft. on the edge of the bank, 10 ft. above high water. The sediment from the tanks is run off into the river. The settled water is pumped by two Worthington duplex pumps of 1½ million gallons capacity each, into the distributing mains and a circular wooden tank, 20 ft. in diameter and 16 ft. high, set on a brick tower, 25 ft. square and 40 ft. high, on the hill back of the city. The water level in the tank is 318 ft. above low water in the river.

The tanks rests on timber-trussed beams, which are further supported by a timber trestle built in the centre of the tower, and not a part of the original design. All timber work is treated by the Thilmany process, and the brick-work treated with paraffine applied hot to the surface, which was dried by a portable furnace heating 2 ft. square at a time.

Distribution is by cast-iron pipe of 12-in. to 6-in. diameter. There are 7½ miles in use, with 40 fire hydrants and 200 taps. The city pays $100 each per year for fire hydrants.

The population in 1880 was 7,652. The works began operation in Dec., 1881.

The capital stock of the company is $80,000, and the bonded debt is $80,000 at 6 per cent. interest. The works have cost $80,000.

J. W. Ruenzie is the Superintendent.

(TO BE CONTINUED.)

CORRECTION.—March 11, 1882. Alphena, 6th line, for *fine timbers*, read *pine timbers*.

There are no water-works in the following towns included in list of Jan. 28: Northbridge, Mass.; Nebraska City, Neb.

The receipt of statistics as follows is acknowledged with thanks: From Daniel Walden, Superintendent, tenth annual report of the water-works of Lynn, Mass. From R. C. P. Coggeshall, Superintendent, twelfth annual report of the water-works of New Bedford, Mass. From B. E. Lehman, Superintendent, statistics and water rates of the water-works of South Bethlehem, Pa. From O. R. Fyler, Superintendent, statistics of the water-works of Torrington, Conn.

THE ENGLISH CHANNEL TUNNELS.

The channel tunnel, of which readers of the *World* have read so much recently, and which has made such a pother both in the press and in Parliament, may be said to be fairly under way. Indeed, according to a writer in the London *Daily News*, the so-called "experimental works" sanctioned by the government in 1875, have been pushed on so vigorously on the English side that three years and a far less amount of capital than the public supposes will see what was once looked upon as a visionary suggestion transformed into an accomplished fact. Two things only are required for this consummation—full Parliamentary sanction and the absence of any geological fault in the stratum in which the projectors are working. The entrance shaft to the experimental tunnel is sunk in the chalk cliff at the foot of the "Shakespeare Cliff," between Folkestone and Dover, and is about 150 ft. in depth. The opening is circular, with boarded sides. At the bottom of this shaft is a square chamber dug in the gray chalk, the sides of which are protected by heavy beams, and in front is the experimental boring, a low-roofed circular tunnel about 7 ft. in diameter, the floor in which is laid with a double line of tram rails. This tunnel is ventilated, and admirably ventilated, on the pumping system, and on visiting days is lighted with electric lamps, the steam power at the mouth of the shaft being sufficient for all purposes. The stratum through which the experimental borings have been made is the lower gray chalk, a substance that looks like "fuller's earth," and is nearly one-half clay and the other half chalk. This material, while perfectly water-tight, is not harder than tolerably hard cheese. The stuff taken out is easily converted into cement to line the walls of the tunnel when completed at its full diameter of 14 ft. About 100 yards a week have been excavated at present, or at the rate of 3 miles a year, and this quantity could probably be increased. Simultaneous borings from the French side at the same rate—always assuming that no fault is met with in the workings—would give 6 miles a year, or a complete tunnel underneath and across the channel in 3 years and a half. The experimental tunnel now reaches a length of two-thirds of a mile, at about 60 ft. below the level of low-water mark. The direction it takes from the English coast under the sea is toward the end of the Admiralty Pier at Dover and from here it will bend in a curve to the French coast opposite.

On the French coast the company who obtained a concession from the French government in 1875 to construct the southern half of the proposed channel tunnel have made considerable and, so far, satisfactory progress in the examination of the chalk cliffs near Calais, which are believed to be the outcrop of a continuous bed of homogeneous chalk running beneath the sea between the two shores. According to a writer in the London *Times* who visited the place a few days ago—Sangatte, about six miles from Calais—two shafts lined with brick and wood have been sunk. About 70 ft. beneath the surface the borers have found the *craie de Rouen*, a stratum corresponding to the lower portion of the homogeneous gray chalk which English geologists call the "chalk without flints." The lining is carried down to a depth of 204 ft., when the chalk becomes so dry and hard that a lining is no longer required. The depth of the shaft is about 280 ft., and a gallery 8 ft. high and of the same width opens into one of equal diameter running nearly at right angles, which, with a slightly upward inclination, to provide for drainage, runs in a northeasterly direction, but trending to the northward—that is, toward the sea—with a curve having a radius of one kilometer. It is to be 1,850 yards long. Artificial ventilation has not been found necessary so far. This gallery is about 170 ft. below low-water mark, but no portions of these workings have yet been pushed out under the sea. M. Alexandre Lavalley, the contractor for the Suez Canal, is to drive another gallery of equal length in the same direction as, but not immediately over, the one already begun. He will employ Brunton's cutting machine, while in the lower gallery Beaumont's machine will be used, both machines being driven with compressed air. It is found in the lower gallery that there is but little percolation of water, and that such as runs in comes from springs in fissures. What does flow in is pumped out at the rate of 60 gallons per minute.

The Southeastern Railway Company is prosecuting, at its own expense, the scheme first mentioned, but the Channel Tunnel Company has revived its original rival scheme, which, under the management of Sir John Hawkshaw, is being

pushed forward with activity. The English terminus is to be at Bigwin street, in the center of Dover, about 500 yards from the beginning of the tunnel proper. The tunnel will then proceed at a gradient of 1 in 80—the same gradient as the Southeastern scheme—in the direction of Farehole, St. Margaret's Bay, near the South Foreland, where it will leave the English shore, taking a course beneath the channel to meet the heading already commenced at Sangatte. The boring between St. Margaret's and Dover will be commenced at the former place, where drainage works will be constructed, and powerful pumps provided for the water it is expected will find its way into the heading in passing through the hills in the neighborhood of Dover. In the event of the company obtaining the consent of the government to their scheme, and provision having to be made for the Southeastern Railway Company to run over their line, the course which will most probably be adopted will be to connect the town by a tunnel from Shakespeare's Cliff, passing under the Western Heights.

The advantages of the channel tunnel are claimed to be numerous. The abominable channel passage, with the attendant horrors of sea-sickness, will be done away with, and while traffic is increased the time between London and Paris will be reduced from 9-11 hours to six or even five. With compressed air-engines, or probably electrical engines, the passage of the tunnel—twenty-one miles in length—will be made in half an hour, and the rest will depend upon an acceleration of speed on the French side of the railway journey. The advantage to the goods traffic in avoiding transshipments is too obvious to dwell upon. There is no right of way to purchase, and the material is so favorable that—unless a "fault" is developed in the gray chalk—the cost of driving the tunnel will be very small, less indeed than that of many a railroad cutting. The one point on which reform is necessary is the examination of baggage en route, but here probably the example of the American railways crossing into Canada can be followed and baggage examined in transitu or before leaving the terminus. According to the pamphlets issued in 1874 and 1875 the cost of the tunnel was to be £4,000,000, the estimates being, however, raised to £8,000,000 to cover any possible contingency. Sir Edward Watkin now says that working in a dry material so easy of manipulation he can construct the tunnel for a sum "wonderfully less" than any estimate. Colonel Beaumont declares that with one of his improved machines at each end of the tunnel a progress of fifty yards per day can be attained, only two men being employed with each, the machine delivering the material into the carts as it is scooped out. The *British Trade Journal*, however, recently attacked the whole scheme. "In constructing the Kilsby tunnel on the original London & Birmingham Railway," it said, "the engineers encountered a wet stratum, and the consequence was not merely to send up the cost £145 per yard, but to imperil the very construction of the line. The St. Gothard tunnel, the precise cost of which has yet to be ascertained, was estimated at £135 per yard. The Mount Cenis tunnel cast £195 per yard. The Thames tunnel, which is the nearest analogy, £1,299 per yard. The cost, therefore, may vary from £255,000 to £2,000,000 per mile, and assuming that the expense is only £343,000 per mile a traffic of £34,300 per mile a year will be required to pay 5 per cent. on the capital and working expenses. The average gross receipts of the railways in the United Kingdom are less than £3,800 per mile. The only railways that even approach the required sum are the metropolitan lines, which carry 3,500,000 passengers a year in trains following each other at intervals of three or four minutes for eighteen hours out of twenty-four. In 1878 the passenger traffic of the Southeastern Railway, whose chairman, Sir Edward Watkin, is getting up this scheme in the interests of its shareholders, was 71,997 per mile per annum, and if every one of these passengers had been conveyed through the tunnel to France, they would have composed 2 per cent. of the number required." However, the experienee of scientific prophets during the past generation or so has not been of a character completely to dishearten Sir Edward Watkin or Sir John Hawkshaw.

The military aspects of the channel tunnel have been discussed at a length and in a manner that to Americans can only seem comic. Admiral Lord Dunsany, in the *Nineteenth Century*, says: "If the tunnel is made, even its warmest advocates must confess the necessity of such fortifications as shall secure to us the possession of our end of it. These fortifications must be sufficient to render a surprise or an escalade by a small force all but impossible. They must always be kept in the highest state of efficiency, and should be garrisoned by picked troops." Whatever contrivances might be invented for blowing up the tunnel and letting in the sea at a moment's notice, there would be no security against their being seized by a sudden night attack on the part of a couple of thousand men. "The enemy," urges Lord Dunsany, "who siezes our end of the tunnel will be masters of it; and as we are told that trains can easily be run the distance between France and England in half an hour, and that, as there are to be two lines of rails in the tunnel, trains can follow one another safely at intervals of 5 or 6 minutes, before morning broke 20,000 infantry might easily, having come through the tunnel, be in possession of Dover." Those who rely upon the present *entente cordiale* between England and France are warned that there is no guarantee against the sudden appearance of "an ambitious conqueror under the lawyer-like exterior of an elected minister or president," and even if there was no such cause for watchfulness and precaution it is unfair to expose neighbors to "so tremendous a temptation." Sir Garnet Wolseley is a sharer in his views, and they have been persistently echoed by the press. Indeed a brochure, after the fashion of "The Battle of Dorking" only not clever, has been issued and has become quite popular, in which the author describes how a handful of brave Frenchmen, disguised as tourists, obtained possession of the Dover end of the tun nel and facilitated the passage of an army which conquered England. Moltke, on the other hand, laughs at the idea, as he approves of the conclusions of a paper recently prepared by a Prussian officer, to the following effect: "To deprive the enemy of the use of the tunnel and render it impassable in case of a hostile attempt, one or two iron-clad forts should be erected at the mouth. They should be strong enough to resist all ordinary siege guns, while they could be placed so as effectually to enfilade the entrance to the tunnel. Another safeguard would be the construction of mines or chambers filled with explosives, which in case of necessity could be fired and blow up the mouth of the tunnel completely. A surprise might be effectually guarded against by stationing a small body of troops permanently at the mouth of the tunnel, under officers whose duty it would be to see that the strictest discipline was invariably carried out. The supposition of the capture of the tunnel and that its seizure would at once entail the danger of an invasion is based upon mere arbitrary conjectures which require a coincidence and concatenation of circumstances of almost impossible character. It presupposes, firstly, the gravest faults in failing to discern the right moment for taking the necessary precautions for securing the tunnel. Secondly, it assumes that a large body of troops can be conveyed to England without the fact becoming previously known that they were being massed for the purpose. It assumes, thirdly, that such a force could get possession of Dover and other forts, and the English garrison simply allow itself to be taken unawares; and it assumes, fourthly, that France could dispatch 20,000 men through the tunnel in five hours to establish a *tête de pont*. But it is notorious that the conveyance of such numbers secretly is an utter impossibility. To prevent such a *coup de main* as Sir Garnet Wolseley apparently apprehends, military engineers can devise the most perfect and effective means. "The invasion of England through the proposed tunnel I consider impossible. You might as well," said Europe's greatest strategist, pointing to the entrance to his library, "you might as well talk of invading her through that door." Appliances similar to those for blowing up the Rhine bridges at Cologne and Strasburg, which can at any moment be instantaneously done, would prove amply sufficient.—*New York World.*

CORRESPONDENCE.

METRIC LEVELING RODS.

(*Continued from Page 87.*)

leveler the figures indicating units and tenths, even when only a very short length is visible. The second decimal place is obtained by counting not more than *four* centimeter blocks, leaving the third place of decimals to be estimated by the eye.

Two designs for metric leveling rods, divided and marked according to the foregoing principles, are shown below. They are drawn one-half full size.

Design No. 1 is used on the rods of the English telescopic pattern. They may be obtained from any of the leading dealers in engineering supplies. They are four meters in length when extended. When closed their length is about 1.60 m.

Design No. 2 was prepared by the writer about three years ago, and was one of several designs exhibited before the Boston Society of Civil Engineers at the presentation of the annual report of the Standing Metric Committee of that Society in the spring of 1879. This design is well adapted for a target rod, since all the centimeter blocks are on one side of the rod.

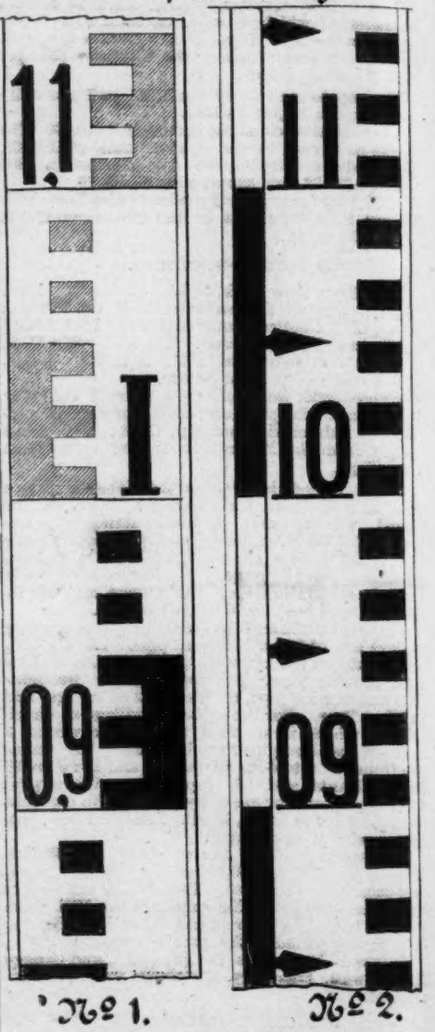
This communication would not be complete did it not contain a brief description of the peculiar leveling rods used by the French engineers.

The leveling instruments used in France are so constructed that the telescope may be reversed and inverted without turning the instrument upon its vertical axis, the level tube being on the bar of the instrument.

It follows from this construction that if two readings of the rod are taken, one with a direct telescope and the other with the telescope reversed and inverted, the average of the two will be a reading from which any errors due to imperfect adjustment of the instrument, or to irregular expansion of the level tube by heat, will have been eliminated.

This principle is made the basis of the French

Metric Leveling Rods.
One-half size.
The shaded portion may be red.



No 1. No 2.

system of leveling, by which heights are obtained by the average of two operations, with very rare exceptions.

Now the average of two quantities a and b may be written—

$$\frac{a}{2}+\frac{b}{2}$$

a and b representing the two readings of the rod. The two half-readings of the formula are not obtained in the field by a division by two, which would involve great labor, but by marking the rod to a unit of *double size*, by which means the half-reading may be read directly from the rod. Thus, a length of *two meters* is taken, divided into tenths and hundredths, and numbered as if it were the unit of measure. The two designs above shown may be considered as representing rods of this character at a scale of *one-quarter* full size.

Another modification used in France, to gain greater distinctness in long sights, is to divide the artificial tenths on the rod into *five* parts of 4 centimeters, instead of ten parts of 2 centimeters each. These rods are read by estimating the *twentieth* parts of the divisions by the eye to obtain the third decimal figure. They are very extensively used.

CHARLES H. SWAN, C. E.,
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